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EFFECT OF BOW-DOWN TRIM ON THE RESISTANCE CHARACTERISTICS OF THE AO 177 HULL REPRESENTED BY MODEL 5326

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Bethesda, Maryland 20084

EFFECT OF BOW-DOWN TRIM ON THE RESISTANCE CHARACTERISTICS OF THE AO 177 HULL REPRESENTED BY MODEL 5326

by

William G. Day, Jr. and Douglas S. Jenkins

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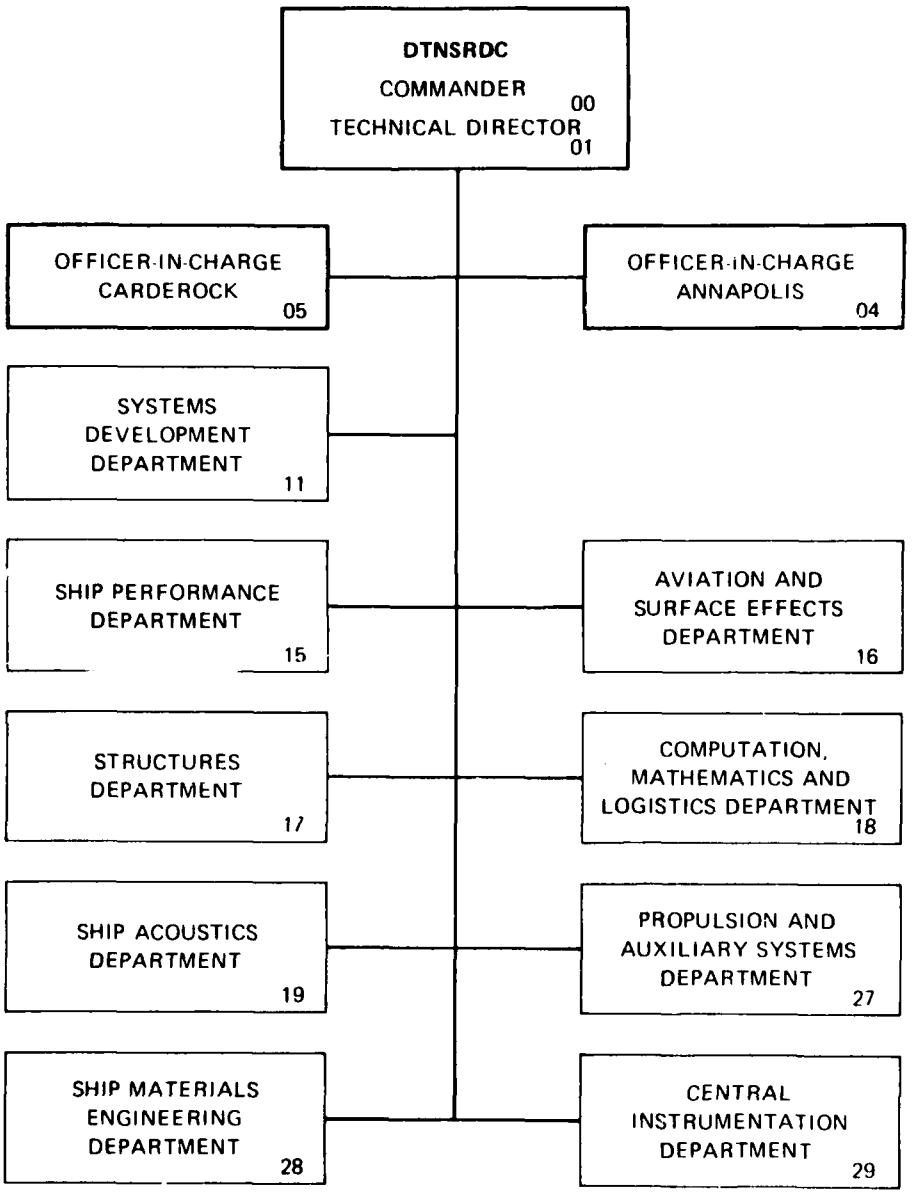

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Experiments were performed with a 1:25.682-scale model of the AO 177 to determine the effect of bow-down trim on the resistance of the hull. The three full-scale trim conditions represented were 1.5-foot (0.46 m) trim by the stern, 1.0-foot (0.3 m) trim by the bow, and 3.5-foot (1.07 m) trim by the bow. The results indicate a small increase in resistance at the 21.5-knot design speed with increasing trim by the bow.

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ABSTRACT

Experiments were performed with a 1:25.682-scale model of the AO 177 to determine the effect of bow-down trim on the resistance of the hull. The three full-scale trim conditions represented were 1.5-foot (0.46 m) trim by the stern, 1.0-foot (0.3 m) trim by the bow, and 3.5-foot (1.07 m) trim by the bow. The results indicate a small increase in resistance at the 21.5-knot design speed with increasing trim by the bow.

ADMINISTRATIVE INFORMATION

The work reported herein was performed for the Naval Sea Systems Command (NAVSEA) under funding provided in Work Request Number N0002480WROH301 dated February 1980. The David W. Taylor Naval Ship R&D Center (DTNSRDC) Work Unit Number was 1-1524-714.

INTRODUCTION

The contract design of the AO 177 Auxiliary Oiler represented by DTNSRDC Model 5326 was designed to have an at-rest trim of 1.5 feet (0.46 m) by the stern. The design displacement is 27,390 tons (27 820 metric tons), at a mean draft of 22.5 feet (6.9 m). When the ship was launched, it assumed an at-rest trim of approximately 3.5 feet (1.1 m) by the bow. The Naval Sea Systems Command (NAVSEA 3213) initiated a model test program in the Ship Performance Department at DTNSRDC to determine the effects of such a change in trim on both the effective power requirements and the maneuvering characteristics of the AO 177 hull. The Design Evaluation Branch (Code 1524) was tasked to perform model resistance experiments at 3 trim conditions to determine changes in drag due to the trim. The Surface Ship Dynamics Branch (Code 1568) was tasked to perform turning and maneuvering experiments to determine the effects of bow-down trim on maneuvering characteristics of AO 177.

This report presents a brief description of the model and experimental conditions for the resistance experiments. The results showing drag increase with bow-down trim are presented. The results of the turning and maneuvering experiments will be presented in a separate report.

DESCRIPTION OF MODEL AND EXPERIMENTS

DTNSRDC Model 5326-1 represents the AO 177 to a scale ratio of 25.682. For the resistance experiments reported herein the model was fitted with rudder, bilge keels and the final design bulbous bow configuration. Additional details of model configuration are presented in Reference (1).

The model was ballasted to the design displacement representing 27,390 tons (27 820 metric tons) and trimmed to represent 3 trim conditions: 1.5 feet (0.46 m) trim by the stern, 1.0 feet (0.3 m) trim by the bow and 3.5 feet (1.1 m) trim by the bow. Resistance experiments were performed on towing Carriage 1 in the deep water basin of DTNSRDC, using standard equipment and procedures.

PRESENTATION AND DISCUSSION OF RESULTS

The results of the resistance experiments are presented in Tables 1 through 3 and Figure 1. Effective power predictions have been made using the 1957 ITTC Ship-Model Correlation Line and a correlation allowance of 0.0005. Full scale effective power predictions are for the ship operating in smooth, deep salt water at 15^{o} Celsius. Still-air drag and service margin have not been added to these effective power predictions. The effect of trim on resistance may be determined from comparison of the straightforward extrapolation of model experimental data, since wind drag and service margin corrections would merely be constant values added to all of the experimental data.

Table 4 assembles the effective horsepower predictions for all three trim conditions in the speed range from 18 to 22 knots. The predictions of effective power at the design speed of 21.5 knots have been plotted as a function of trim in Figure 2.

The resistance of the AO 177 hull at the design condition (1.5 foot (0.46 m) trim by the stern) repeated results of earlier experiments.[1] The resistance

[1] References are listed on page 4 .

of the hull with the large bow-down trim of 3.5 feet (1.1 m) increased by approximately one and one half percent at the 21.5 knot design speed. The resistance of the hull with 1.0 foot (0.3 m) trim by the bow is only one-half percent higher than the resistance at the design condition. The small change in resistance is shown in Figures 1 and 2. From the data presented in these figures and in the tables it may be concluded that the effects of the bow-down trim on the resistance of the AO 177 hull are small.

The accuracy of the experimental measurements is approximately plus or minus one and one half percent, so the differences shown in these results are less than or equal to the inaccuracy of measurement. Nevertheless, the experiments showed a consistent trend of increasing resistance with increasing trim by the bow. This trend is considered valid.

REFERENCES

1. Hendrican, A. and K. Remmers, "Powering and Cavitation Performance for a Naval Fleet Oiler, AO 177 Class (Model 5326 with Propeller 4677)," DTNSRDC Ship Performance Department Report 544-14 (Jan 1976).

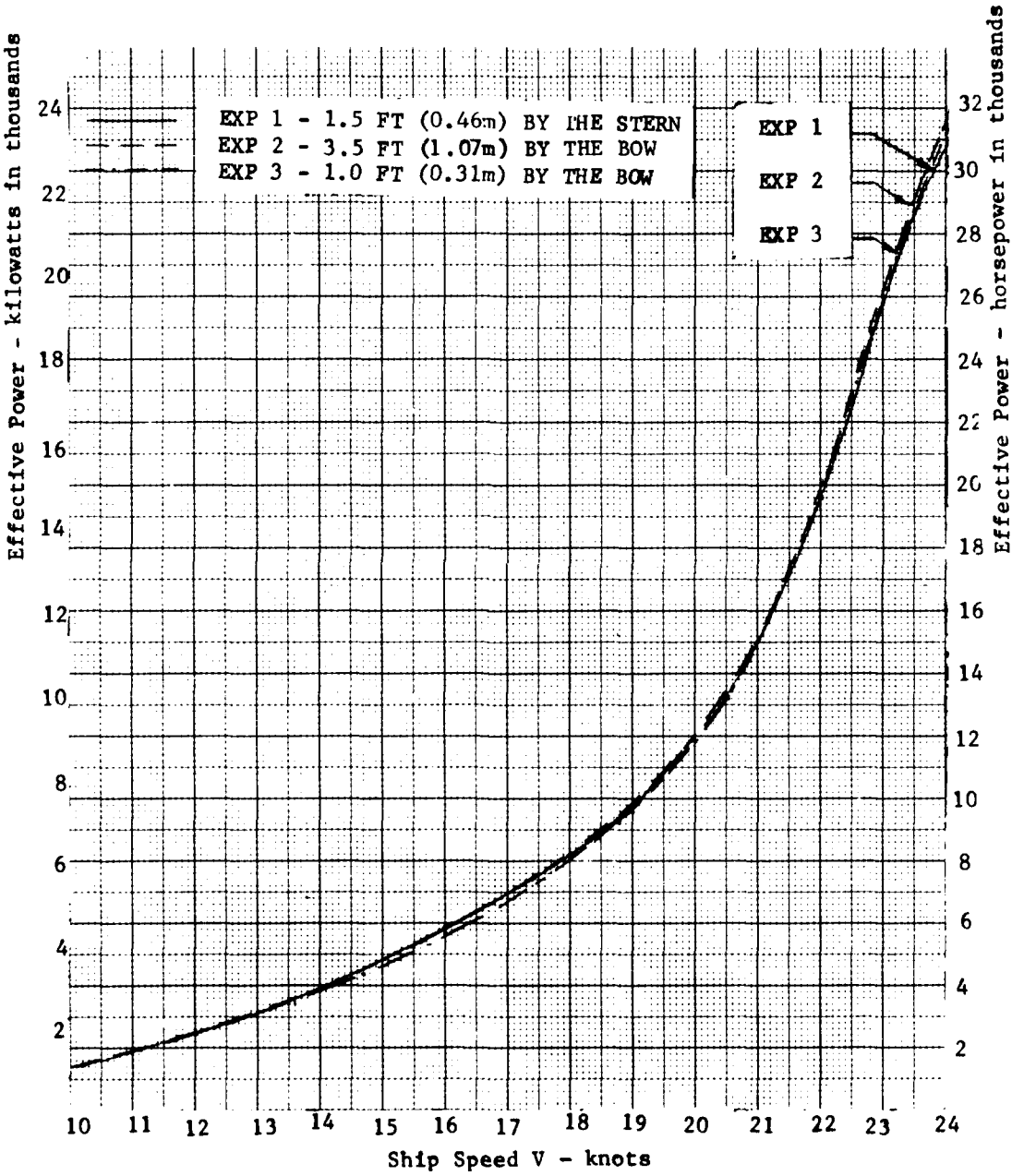

FIGURE 1 - Effective Powering Predictions for AO 177 represented by Model 5326, at Design Displacement and three trimmed conditions

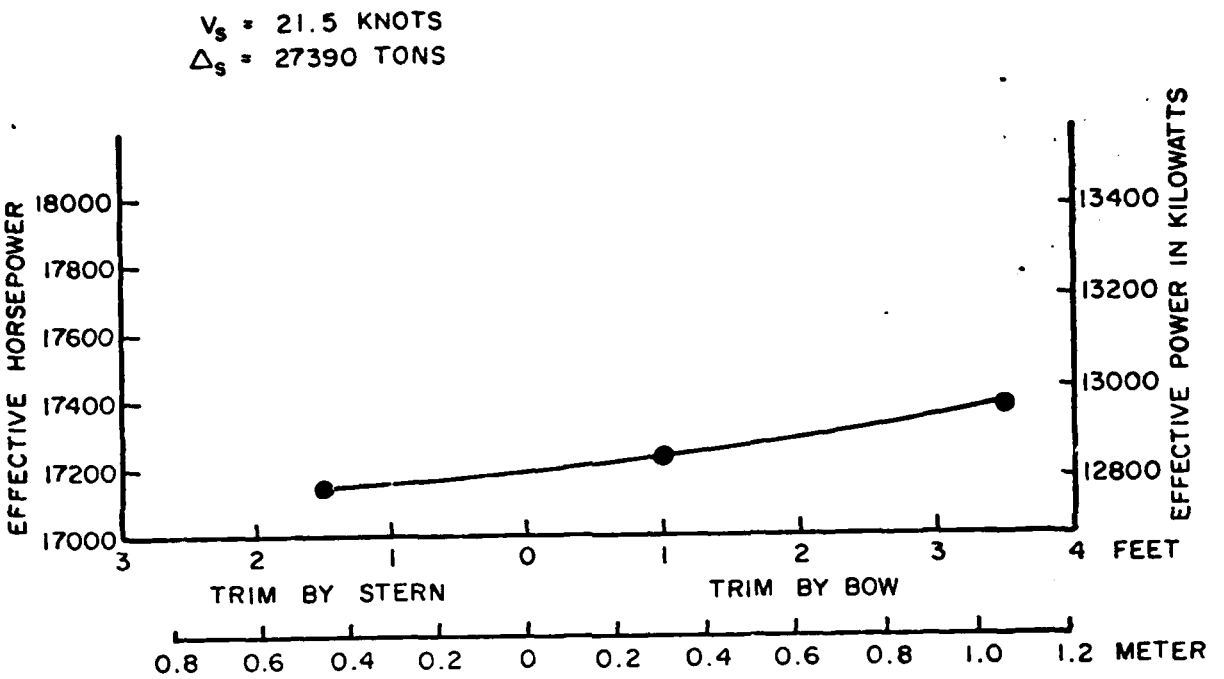

Figure 2 - Effective Power Requirement for AO 177 at 21.5 Knots in Various Trim Conditions

TABLE 1 - EFFECTIVE POWERING PREDICTIONS FOR AO 177 REPRESENTED BY MODEL 5326, DESIGN DISPLACEMENT, TRIMMED 1.5 FT (0.46m) BY THE STERN

	SHIP	MODEL
LENGTH	560.64 FT (170.9 M)	21.83 FT (6.654 M)
WETTED SURFACE	63200.SQ FT (5871. SQ M)	95.82 SQ FT (8.90 SQ M)
DISPLACEMENT	27386.TONS (27825. T)	1.57 TONS (1.60 T)

LINEAR RATIO 25.682
ITTC FRICTION LINE
CORRELATION ALLOWANCE (CA) .00050

VS		PE		FRICTIONAL POWER		FN	V-L	1000CR
KNOTS	MVS	HP	KW	H	KW			
10.00	5.14	1460.9	1089.4	1149.2	856.9	.126	.422	.567
12.00	6.17	2490.2	1857.0	1951.5	1455.2	.151	.507	.567
14.00	7.20	3909.9	2915.6	3054.4	2277.6	.176	.591	.567
16.00	8.23	5751.0	4288.5	4503.2	3358.1	.201	.676	.554
18.00	9.26	8119.6	6054.8	6343.0	4730.0	.226	.760	.554
19.00	9.77	9539.2	7113.4	7423.4	5535.6	.239	.802	.561
20.00	10.29	11728.2	8745.7	8618.2	6426.6	.251	.845	.707
20.50	10.55	13220.5	9858.5	9260.3	6905.4	.258	.866	.836
21.00	10.80	15030.3	11208.1	9933.0	7407.0	.264	.887	1.001
21.50	11.06	17140.0	12781.3	10637.0	7932.0	.270	.908	1.190
22.00	11.32	19629.5	14636.9	11373.1	8480.9	.276	.929	1.410
23.00	11.83	25688.7	19156.1	12944.0	9652.4	.289	.971	1.905
24.00	12.35	30940.8	23072.5	14651.3	10925.5	.302	1.014	2.143

TABLE 2 - EFFECTIVE POWERING PREDICTIONS FOR AO 177 REPRESENTED BY MODEL 5326,
DESIGN DISPLACEMENT, TRIMMED 3.5 FT (1.07m) BY THE BOW

	SHIP	MODEL
LENGTH	560.64 FT (170.9 M)	21.83 FT (6.654 M)
WETTED SURFACE	63021.SQ FT (5855. SQ M)	95.55 SQ FT (8.88 SQ M)
DISPLACEMENT	27386.TONS (27825. T)	1.57 TONS (1.60 T)

LINEAR RATIO 25.632
ITTC FRICTION LINE
CORRELATION ALLOWANCE (CA) .00050

VS		PE		FRICTIONAL POWER		FN		1000CR
KNOTS	M/S	HP	KW	H	KW			
10.00	5.14	1455.8	1085.3	1145.9	854.5	.126	.422	.567
12.00	6.17	2483.2	1851.7	1945.0	1451.1	.151	.507	.567
14.00	7.20	3907.8	2914.1	3045.7	2271.2	.176	.591	.573
16.00	8.23	5813.3	4335.0	4490.5	3349.6	.201	.676	.589
18.00	9.26	8275.7	6171.2	6325.1	4716.6	.226	.760	.610
19.00	9.77	9674.0	7213.9	7402.4	5520.0	.239	.802	.604
20.00	10.29	11853.0	8838.8	8593.9	6408.4	.251	.845	.743
20.50	10.55	13291.7	9911.6	9234.1	6885.9	.258	.867	.859
21.00	10.80	15241.7	11365.7	9904.9	7386.1	.264	.888	1.051
21.50	11.06	17374.9	12956.4	10605.9	7909.6	.270	.908	1.242
22.00	11.32	19805.5	14769.7	11340.9	8456.9	.276	.929	1.450
23.00	11.83	26063.0	19435.2	12907.4	9625.1	.289	.971	1.972
24.00	12.35	31580.9	23549.9	14609.9	10894.6	.302	1.014	2.239

TABLE 3 - EFFECTIVE POWERING PREDICTIONS FOR AO 177 REPRESENTED BY MODEL 5326, DESIGN DISPLACEMENT, TRIMMED 1.0 FT (0.31m) BY THE BOW

	SHIP	MODEL
LENGTH	560.64 FT (170.9 M)	21.83 FT (6.654 M)
WETTED SURFACE	62880.SQ FT (5842. SQ M)	95.34 SQ FT (8.86 SQ M)
DISPLACEMENT	27386.TONS (27825. T)	1.57 TONS (1.60 T)

LINEAR RATIO 25.682
ITTC FRICTION LINE
CORRELATION ALLOWANCE (CA) .00050

VS		PE		FRICTIONAL POWER		FN	V-L	1000CR
KNOTS	M/S	HP	KW	H	KW			
10.00	5.14	1453.5	1083.9	1143.3	852.6	.126	.422	.567
12.00	6.17	2477.6	1847.6	1941.6	1447.9	.151	.507	.567
14.00	7.20	3890.1	2900.8	3038.9	2266.1	.176	.591	.567
16.00	8.23	5746.5	4285.2	4480.4	3341.1	.201	.676	.565
18.00	9.26	8206.1	6119.3	6310.9	4706.0	.226	.760	.594
19.00	9.77	9573.5	7139.0	7385.9	5507.6	.239	.802	.583
20.00	10.29	11686.4	8714.5	8574.6	6394.1	.251	.845	.711
20.50	10.55	13163.0	9815.6	9213.4	6870.4	.258	.866	.838
21.00	10.80	15101.1	11260.9	9882.7	7369.5	.264	.887	1.030
21.50	11.06	17221.8	12842.3	10583.2	7891.9	.270	.908	1.221
22.00	11.32	19628.1	14636.7	11315.5	8438.0	.276	.929	1.427
23.00	11.83	25959.1	19356.9	12878.5	9603.5	.289	.971	1.965
24.00	12.35	31374.1	23395.6	14577.2	10870.2	.302	1.014	2.221

TABLE 4

COMPARISON OF EFFECTIVE POWER PREDICTIONS FOR AO 177 REPRESENTED BY MODEL 5326, DESIGN DISPLACEMENT, FULLY APPENDED, AT THREE TRIMMED CONDITIONS: 1.5 X FT X STERN, 3.5 FT X BOW, AND 1.0 FT X BOW

V-KNOTS	EXP 1 P_E-h_p 1.5 FT X STERN	EXP 2 P_E-h_p 3.5 FT X BOW	EXP 3 P_E-h_p 1.0 FT X BOW
18.0	8120	8276	8206
20.0	11728	11853	11686
20.5	13221	13292	13163
21.0	15030	15242	15101
21.5	17140	17375	17222
22.0	19629	19807	19628

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